CLAIMS

1. A semiconductor device comprising:

a semiconductor substrate;

a source region and a drain region, which are formed on the semiconductor substrate with a channel region therebetween;

a floating gate electrode that is formed on the channel region with a gate insulator film therebetween;

a ferroelectric film that is formed on the floating gate electrode; and

a control gate electrode that is formed on the ferroelectric film;

wherein an intermediate insulator film is formed between at least one of the pairs consisting of the floating gate electrode and the ferroelectric film, and the ferroelectric film and the control gate electrode; and

the intermediate insulator film is made of a hafnium oxide that contains nitrogen atoms.

2. The semiconductor device according to Claim 1, wherein intermediate insulator films are formed both between the floating gate electrode and the ferroelectric film, and between the ferroelectric film and the control gate electrode.

3. The semiconductor device according to Claim 1, wherein the gate insulator film is made of hafnium oxide that contains nitrogen atoms.

4. The semiconductor device according to Claim 1, wherein the intermediate insulator film contains nitrogen atoms of not less than 0.1 atomic % and not more than 30.0 atomic %.

5. The semiconductor device according to Claim 1, wherein the intermediate insulator film contains nitrogen atoms of not less than 0.5 atomic % and not more than 10.0 atomic %.

6. The semiconductor device according to Claim 1, wherein the intermediate insulator film contains nitrogen atoms of not less than 1.0 atomic % and not more than 6.0 atomic %.

7. A method for fabricating a semiconductor device, which comprises the steps of:

forming a floating gate electrode on a semiconductor substrate with a gate insulator film therebetween;

forming a ferroelectric film on the floating

gate electrode;

forming a control gate electrode on the ferroelectric film; and

forming a source region and a drain region on the semiconductor substrate;

which further comprises the step of:

forming an intermediate insulator film between at least one of the pairs consisting of the floating gate electrode and the ferroelectric film, and the ferroelectric film and the floating gate electrode;

wherein the intermediate insulator film is formed using hafnium or compounds thereof as a target, and sputtering by introducing a gas that contains argon, oxygen, and nitrogen into the film-formation space.

8. The method for fabricating a semiconductor device according to Claim 7, wherein the ratio of the flow rate of the nitrogen gas to the total flow rate of the oxygen gas and the nitrogen gas that flow into the film-formation space is not smaller than 0.05 and not more than 0.90.

9. The method for fabricating a semiconductor device according to Claim 7, wherein the ratio of the flow rate of the nitrogen gas to the total flow rate of

the oxygen gas and the nitrogen gas that flow into the film-formation space is not smaller than 0.1 and not more than 0.4.

10. The method for fabricating a semiconductor device according to Claim 7, which further comprises an annealing step that is conducted after forming each intermediate insulator film or the control gate electrode.

11. The method for fabricating a semiconductor device according to Claim 10, wherein the annealing is conducted at a temperature of not lower than 200°C and not higher than 1,100°C.

12. A method for fabricating a semiconductor device, which comprises the steps of:

forming a floating gate electrode on a semiconductor substrate with a gate insulator film therebetween;

forming a ferroelectric film on the floating gate electrode;

forming a control gate electrode on the ferroelectric film; and

forming a source region and a drain region on the semiconductor substrate;

which further comprises the step of:

forming an intermediate insulator film between at least one of the pairs consisting of the floating gate electrode and the ferroelectric film, and the ferroelectric film and the floating gate electrode;

wherein the intermediate insulator film is formed by MOCVD using a gas made of organic metal compounds that contain hafnium, a gas containing oxygen atoms, and a gas containing nitrogen atoms, as a source gas.

13. The method for fabricating a semiconductor device according to Claim 12, wherein the ratio of the flow rate of the gas containing nitrogen atoms to the total flow rate of the gas containing oxygen atoms and the gas containing nitrogen atoms that flow into the film-formation space is not smaller than 0.05 and not more than 0.90.

14. The method for fabricating a semiconductor device according to Claim 12, wherein the ratio of the flow rate of the gas containing nitrogen atoms to the total flow rate of the gas containing oxygen atoms and the gas containing nitrogen atoms that flow into the film-formation space is not smaller than 0.1 and not more than

0.4.

15. The method for fabricating a semiconductor device according to Claim 12, which further comprises an annealing step that is conducted after forming each intermediate insulator film or the control gate electrode.

16. The method for fabricating a semiconductor device according to Claim 15, wherein the annealing is conducted at a temperature of not lower than 200°C and not higher than 1,100°C.

17. A method for fabricating a semiconductor device, which comprises the steps of:

forming a floating gate electrode on a semiconductor substrate with a gate insulator film therebetween;

forming a ferroelectric film on the floating gate electrode;

forming a control gate electrode on the ferroelectric film; and

forming a source region and a drain region on the semiconductor substrate;

which further comprises the step of:

forming at least one intermediate insulator film

between at least one of the pairs consisting of the floating gate electrode and the ferroelectric film, and the ferroelectric film and the floating gate electrode;

wherein the intermediate insulator film is formed by ALD using $HfCl_4$ gas, H_2O gas, and a gas containing nitrogen atoms, as a source gas.

18. The method for fabricating a semiconductor device according to Claim 17, wherein the ratio of the flow rate of the gas containing nitrogen atoms to the total flow rate of the H_2O gas and the gas containing nitrogen atoms that flow into the film-formation space is not smaller than 0.05 and not more than 0.90.

19. The method for fabricating a semiconductor device according to Claim 17, wherein the ratio of the flow rate of the gas containing nitrogen atoms to the total flow rate of the H_2O gas and the gas containing nitrogen atoms that flow into the film-formation space is not smaller than 0.1 and not more than 0.4.

20. The method for fabricating a semiconductor device according to Claim 17, which further comprises an annealing step that is conducted after forming each intermediate insulator film or the control gate electrode.

21. The method for fabricating a semiconductor device according to Claim 20, wherein the annealing is conducted at a temperature of not lower than 200° C and not higher than 1,100° C.